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NATIONAL BUREAU OF STANDARDS REPORT

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PERFORMANCE REQUIREMENTS AND GUIDE CRITERIA FOR FINISH FLOORS

Proposed Changes in
NBS Guide Criteria for the
Design and Evaluation of
OPERATION BREAKTHROUGH
Housing Systems

Sponsored by
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT



U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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PERFORMANCE REQUIREMENTS AND GUIDE CRITERIA FOR FINISH FLOORS

Proposed Changes in

NBS Guide Criteria for the
Design and Evaluation of
OPERATION BREAKTHROUGH
Housing Systems

By

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Sponsored by

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

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PERFORMANCE REQUIREMENTS AND GUIDE CRITERIA FOR FINISH FLOORS

I N T R O D U C T I O N

In the preparation of such a massive and pioneering document as GUIDE CRITERIA for the Design and Evaluation of OPERATION BREAKTHROUGH, there are apt to be omissions and repetitions. It is obvious from a cursory examination that the four volumes are redundant, which may lead to consolidation. The list of Performance Requirements in the APPENDIX of this report shows redundancy in many of the Requirements, which are repeated for various Built Elements almost word for word. There is an important omission in Chapter D, which fails to treat floor coverings adequately and this is the subject of this report. The proposed changes lead to further redundancy but it is probably necessary to repeat requirements for various built elements in order to assure satisfaction with respect to each building component.

For the benefit of those who are not familiar with the structure of the GUIDE CRITERIA, a list and directory of the performance requirements appear in the APPENDIX to this report. The four volumes of GUIDE CRITERIA are:

- Volume I - Multifamily High Rise
- Volume II - Multifamily Low Rise
- Volume III - Single Family Attached
- Volume IV - Single Family Detached

DISCUSSION OF CHAPTER D, INTERIOR SPACE DIVIDERS, FLOOR-CEILING

The floor-ceiling sandwich, like the other Built Elements in GUIDE CRITERIA, is considered as a system. The finish floor is a subsystem within the floor-ceiling system or a sub-element within the floor-ceiling element. In the proposed revision of Chapter D (FLOOR-CEILING), the word "finish floor" is used to include flooring, floor coverings, and floor surfacings and coatings. Wooden flooring, such as strip oak or maple or parquet, are finish floors but are a part of the building structure, as they have load bearing capacity and are permanently attached to the subfloor. Floor coverings, coatings, and surfacings are not a structural part of the building and are applied after the structural elements are completed. Floor coverings, coatings, and surfacings are usually not permanent and are not expected to remain or last for the life of the building. The term "finish floor" as used in the proposed revision of Chapter D means the sub-element within the floor-ceiling element which includes the surface on which people walk on which furniture is placed, whether it be strip oak, parquet, vinyl asbestos tile, carpet, or any other finish floor. If no floor covering,

monolithic surfacing, or coating is applied and the subfloor is concrete, the finish floor would be the concrete surface. In this case, the finish of the concrete would be important. If the concrete were covered with deck enamel, the finish floor would be the coating.

PROPOSED REVISION OF SECTION D
GUIDE CRITERIA FOR OPERATION BREAKTHROUGH

1. Add the following paragraph at the beginning of the chapter:

"This chapter compromises requirements and guide criteria for the entire floor-ceiling element or system, including the finish floor. By finish floor is meant the sub-element within the floor-ceiling element which includes the surface in which people walk and on which furniture is placed. The following are included in finish floors:

Wooden flooring such as strip oak or maple, parquet, block flooring, Floor coverings such as asphalt and vinyl asbestos tile, vinyl tile, sheet vinyl, linoleum, ceramic tile.

Floor coatings such as deck enamel. Products such as sealer, varnish and shellac, applied to wooden flooring, would be considered as finishes for the same.

Floor surfacings to include all types of monolithic surfacings or "seamless floors", as terrazzo (cement or thinset), trowel-on resinous surfacings, brush-on or roll-on "seamless floors".

2. Make the following changes in the REQUIREMENT DIRECTORY:

Under 3 HEALTH AND SAFETY

Add D.3.2 Finish Floor

Under 4 FIRE SAFETY

Add D.4.5 Finish Floor

Under 5 ACOUSTIC ENVIRONMENT

Add D.5.2 Finish floor

Under 8 DURABILITY/TIME RELIABILITY (FUNCTION)

Delete present requirements D.8.1 and D.8.2.

Add the following:

D.8.1 Finish floor - bond, protection of subfloor

D.8.2 Finish floor - chemical resistance

D.8.3 Finish floor - comfort

D.8.4 Finish floor - life-cost

3. Make the following changes in requirements and criteria:

(a) Delete present requirements D.8.1 and D.8.2 and criteria under same.

(b) Add the following requirements and criteria:

*Requirement D.3.2

The finish floor should not present hazards to health and safety.

*Criterion D.3.2.1

The finish floor should be capable of being maintained in a sanitary condition without excessive maintenance cost.

*Test

Comparison with finish floors previously used in similar locations by practical service tests and observations.

*Criterion D.3.2.2

The finish floor should not contribute to accidents from falls due to slipperiness or to a surface which is likely to cause tripping. See L.3.2

*Criterion D.3.2.3

The finish floor should be designed and capable of being maintained such that, under the use for which

*Criterion D.3.2.3 - cont'd

it is designed, persons walking on the surface will not develop static charge sufficient to cause sparks, shock or physical discomfort.

*Test

Comparison with finish floors previously used in similar locations by practical service tests and observations.

*Criterion D.3.2.4

The finish floor should not shed dirt, dust, lint, or any substance contributing to air pollution and which might endanger health or cause an allergic reaction. It should be capable of being maintained in a condition which will not contribute to air pollution without excessive maintenance cost.

*Test

Comparison with finish floors previously used in similar locations by practical service tests and observations.

*Requirement D.4.5

The finish floor should not present a fire hazard.

*Criterion D.4.5.1

The finish floor should not be susceptible to ignition from conditions of normal use, as accidental contact with cigarettes or matches.

*Test

Proposed Flammability Standard for Carpets and Rugs, U. S. Department of Commerce, Federal Register, vol. 34, No. 242, pages 19812-4, Thursday, December 18, 1969.

*Criterion D.4.5.2

The flame spread characteristics of the finish floor should relate to the room use. See D.4.2.

*Criterion D.4.5.3

The finish floor should not contribute a significant amount of heat to a fire. See D.4.4.

*Criterion D.4.5.4

The finish floor should not generate smoke products during a fire which will exceed safe limits. See D.4.3.

*Requirement D.5.2

Finish floors should reduce noise as required in service and meet requirements as they are stated.

*Criterion D.5.2.1

It is desirable that finish floors should assist in the control of noise in residential interior spaces. See L.5.1.

*Requirement D.8.1

The finish floor should remain attached to the subfloor.

*Test

Using the flooring material and techniques to be used in the area, install sections about 3 feet square, spaced approximately 50 feet apart throughout the subfloor area. Bond can be considered satisfactory if after two weeks unusual force is required to lift or pry it from the subfloor.

*Criterion D.8.1.2

The finish floor should be resistant to permanent indentation from concentrated loads and should compare favorably with finish floors commonly used in given areas when evaluated by Test 1; the finish floor should not have a residual indentation of more than 0.007 inch when evaluated by Test 2.

*Test 1

Section 6, ASTM D2394 - 69

*Test 2

Section 4.6.4, Federal Specification L-F-475a

*Criterion D.8.1.3

The finish floor should be resistant to water penetration, as determined by the Moisture Resistance Test.

*Test

Moisture Resistance Test, par. 4.4.4, Federal Specification TT-C-00555

*Requirement D.8.2

Finish floors should be resistant to water, solvents, cooking grease, detergents and household chemicals as encountered in normal service where used, as in bathrooms, kitchens and laundry areas.

*Criterion D.8.2.1, See D.8.1.3

*Criterion D.8.2.2

The finish floor should be resistant to solvents, cooking fats and oils, and household chemicals. The finish floor should not change color when exposed to the solvents listed in the test. The width of the scratch on the floor covering, etc. shall not be more than 0.100 inch when exposed to isopropyl alcohol, beef tallow, mineral oil, and cottonseed oil, as specified in the test. After exposure to 5 percent solutions of sodium hydroxide, acetic acid, and sulfuric acid, the width of the scratch shall not exceed 0.120 inch when tested as specified.

*Test

Section 4.6.7, Federal Specification L-F-475a

*Requirement D.8.3

Finish floors should be as comfortable to walk on as required in service and meet requirements as they are stated.

*Criterion D.8.3.1

For areas in which soft finish floors are desired, the finish floor should have resilience as related to foot comfort, which should be defined.

*Test

Comparison with finish floors previously used in similar locations by practical service tests and observations.

*Requirement D.8.4

A reasonable life expectancy and life-cost of finish floors should be defined, considering retention of desirable properties.

*Criterion D.8.4.1

- (a) Quality of materials. Finish floors should conform to applicable generally accepted standards with respect to all requirements in Section D.
- (b) Installation. Installation of finish floors should comply with recognized standards and/or generally accepted good engineering and trade practices. This covers items such as surface preparation, kind and quality of underlayment, adhesives, primers, and sealers, as required.

A P P E N D I X

Guide Criteria for the Design and Evaluation of OPERATION BREAKTHROUGH

PERFORMANCE REQUIREMENTS - VOLUME 1 (MFHR) (as of November 3, 1970)

- A.1.1 The serviceability of the building should not be impaired by excessive vertical deflection.
- A.1.2 Service windload should not cause discomfort to occupants or impair the serviceability of the structure as a result of drift.
- A.1.3 Horizontal deflections of vertical structural elements between two successive levels of horizontal support should not impair the serviceability of the structure.
- A.1.4 The serviceability of the building should not be impaired by a reasonable amount of foundation settlement.
- A.1.5 Structural vibrations should not cause discomfort to occupants and should not impair structural serviceability.
- A.1.6 Structural elements should not be subject to local damage by loads resulting from occupancy.
- A.1.7 Structural elements should not be damaged and their serviceability should not be impaired by loads resulting from changes in the volume of structural elements.

- A.2.1 An acceptable level of protection against structural failure under extreme loads should be provided.
- A.2.2 An acceptable level of protection against structural failure under repeated application of service loads should be provided.
- A.2.3 Incremental, irrecoverable deformation due to high loads, sustained for extended periods of time, should not cause progressive structural failure.
- A.2.4 An explosion caused by a service system on any one story level should not cause progressive structural collapse at other levels.
- A.2.5 An acceptable level of protection against structural failure due to differential foundation settlement should be provided.
- A.2.6 Inserts and hangers should not fail and/or damage the structural elements to which they are attached.
- A.2.7 Structural safety should be unimpaired by the installation of service-system elements.

- A.3.1 See A.2 and A.4

- A.4.1 The structure should retain its integrity for sufficient time to permit evacuation of the building and for fire fighters to bring the fire under control.

- A.4.2 The structure should not contribute a significant amount of heat to the fire.
- A.4.3 Approved fire protection material should remain intact and fulfill its functions during the life of the building.
- A.5.1 There should be control of generation and transmission of vibration that results in airborne sound radiation.
- A.6.1 No requirement at present.
- A.7.1 See Criterion A.1.3.1 and Criteria for Physical Simulation.
- A.8.1 There should be protection of structural components from condensed moisture that could impair their structural adequacy through deterioration, in those areas of the country where such condensation is possible.
- A.8.2 The materials used in structural elements, components and assemblies should be resistant to or protected from exposure to normal climatic conditions.
- A.8.3 Excessive static and dynamic deflections should not impair the durability of building materials.
- A.9.1 No requirement at present.
- B.1.1 Horizontal deflections should not impair the serviceability of inter-dwelling space dividers (walls, doors).
- B.1.2 The serviceability of inter-dwelling units should not be impaired by a reasonable amount of foundation settlement.
- B.1.3 Inter-dwelling walls should not be damaged by occupancy loads.
- B.2.1 An acceptable level of protection against structural failure under extreme loads should be provided.
- B.3.1 See B.2, B.4, and L.4.
- B.4.1 The walls should be able to contain the fire for a sufficient period to permit evacuation of occupants and for fire fighters to bring the fire under control.
- B.4.2 The flame spread characteristics of the walls should relate to the room use.
- B.4.3 Any smoke products generated by the wall during a fire should not exceed safe limits.
- B.4.4 Walls should not contribute a significant amount of heat to a fire.

- B.5.1 Provision should be made for acoustical privacy between dwelling units.
- B.6.1 See L.6
- B.7.1 No requirement at present.
- B.8.1 For wall surfaces see C.8.1
- B.9.1 For size and location requirements for doors used as exits, see I.4; for other doors, see L.9.
- C.1.1 Requirements and Criteria are the same as those in B.1.
- C.2.1 There should be an acceptable level of protection against structural failure under extreme loads.
- C.3.1 See C.2 and C.4
- C.4.1 The interior partitions should not provide paths for smoke and fire to travel from one floor to the next.
- C.4.2 The flame spread characteristics of the partition should relate to the room use.
- C.4.3 Any smoke products generated by the wall during a fire should not exceed safe limits.
- C.4.4 Bearing walls should be able to sustain the structure for a sufficient time to permit evacuation of occupants and for fire fighters to bring the fire under control.
- C.4.5 Bearing walls should not contribute a significant amount of heat to a fire.
- C.5.1 There should be acoustical privacy within the dwelling unit to create and allow for development of personal and family relationships.
- C.6.1 See L.6
- C.7.1 No requirement at present.
- C.8.1 Wall finish surfaces should be provided which conform to good, accepted practice for a given wall material based on occupancy hazard, esthetics, intended life, and renewability.
- C.9.1 See L.9 for size and location requirements of doors.

- D.1.1 Interior horizontal space dividers or floor-ceiling assemblies should not deflect excessively under service load.
- D.1.2 Floor-ceiling assemblies should not be damaged locally by foundation settlements.
- D.1.3 Vibrations of floors and ceilings should not cause discomfort to occupants and should not impair structural serviceability.
- D.1.4 Floor-ceiling assemblies should not be damaged by occupancy loads.
- D.1.5 Occupancy loads should not impair the serviceability of miscellaneous building element fixtures and service systems associated with the floor-ceiling system.
- D.2.1 Provision should be made for an acceptable level of protection against structural failure under extreme load.
- D.3.1 See D.2, D.4 and L.3.
- D.4.1 The floor-ceiling assembly should contain the fire for a sufficient period to permit evacuation of occupants and to allow fire fighters to bring the fire under control.
- D.4.2 The floor-ceiling sandwich should have flame spread characteristics related to the room use.
- D.4.3 Any smoke generated by the floor-ceiling sandwich in a fire should not exceed safe limits.
- D.4.4 The floor-ceiling sandwich should not contribute a significant amount of heat to a fire.
- D.5.1 Provision should be made for acoustical privacy between dwelling units.
- D.5.2 In the case of a multi-level dwelling unit, there should be acoustical privacy between different levels of the dwelling unit to create and allow for development of personal and family relationships.
- D.6.1 See L.6
- D.7.1 No requirement at present.
- D.8.1 Provision should be made for a level, cleanable and esthetically suitable finished floor wearing surface for living, dining, sleeping and activity areas and for corridors.
- D.8.2 Provision should be made for a level, cleanable, durable and esthetically suitable floor wearing surface for bathrooms, kitchen and laundry areas that shall be resistant to grease (as exposed), water (both liquid and vapor), detergents, and normal household chemicals.

- D.9.1 No requirement at present.
- E.1.1 The exterior wall should not be damaged by occupancy loads.
- E.1.2 Horizontal deflections of the vertical exterior envelope should not impair the serviceability of the structure.
- E.1.3 The serviceability of the vertical exterior envelope should not be impaired by a reasonable amount of foundation settlement.
- E.1.4 The serviceability of the vertical exterior envelope should not be impaired by distortion and volume changes of structural elements (e.g., temperature effects, moisture effects, shrinkage).
- E.2.1 There should be an acceptable level of protection against structural failure under extreme loads.
- E.3.1 See E.2 and E.4. For glass doors see L.3.1.1 (d).
- E.4.1 The walls should prevent the spread of fire through the exterior envelope.
- E.4.2 The surfaces of an exterior wall should not contribute to the spread of flame.
- E.4.3 Any smoke products generated by the wall during a fire should not exceed safe limits.
- E.4.4 The structure should not contribute a significant amount of heat to a fire.
- E.4.5 Transmission of fire and smoke from one floor to another should be prevented.
- E.5.1 Protection should be provided from noise generated by and radiated from the multiplicity of sources outside of the home.
- E.6.1 See L.6.
- E.7.1 Thermal resistance should be provided to limit heat transmission through exterior walls to decrease the cost of air-conditioning (heating and cooling), to improve the comfort of occupants in respect to MRT (mean radiant temperature) and to avoid problems of moisture condensation on wall surfaces.
- E.7.2 Thermal breaks should be provided in high-heat flux through members to prevent condensation.
- E.7.3 Provision should be made to retard the infiltration of air through the exterior wall system.
- E.7.4 Provision should be made to prevent water penetration through the exterior wall.

- E.7.5 Prevent damage or unhealthful conditions caused by infiltration of water or moisture through below-grade foundations into usable space.
- E.7.6 Protection should be provided against water vapor flow or warm air infiltration with consequent cold weather condensation in exterior walls.
- E.7.7 The window should provide the necessary barrier against weather, sound and insects to enable control of the interior environment.
- E.7.8 Exterior doors should satisfy the applicable Criteria listed for windows.

- E.8.1 Provision should be made to limit or control the entrance of water, wind and dirt through spaces between adjoining parts or units of a building. When sealing materials are used, the material should withstand climatic conditions.
- E.8.2 Provision should be made to protect the exterior coating substrate from the deleterious effects of the outdoor environment.
- E.8.3 Camber, lateral bow and buckling of exterior cladding should be controlled within limits which will permit no visual distortion of panels.
- E.8.4 Movement of the structure or components caused by thermal changes should be controlled or considered in design.
- E.8.5 Exterior doors should be constructed of weather-resistant materials and adhesives.

- E.9.1 Provision should be made for surveillance and access to outdoor public child play areas from the interior of dwelling units.
- E.9.2 For other window location requirements see L.6.

- F.1.1 Structural serviceability should not be impaired by excessive vertical deflection.
- F.1.2 Vibrations should not cause discomfort to occupants and should not otherwise impair structural serviceability.

- F.2.1 There should be an acceptable level of protection against structural failure under extreme loads.

- F.3.1 See F.2 and F.4.

- F.4.1 The roof-ceiling assembly should contain the fire for a period long enough to permit evacuation of the occupants and to allow fire fighters to bring the fire under control.
- F.4.2 The roof-ceiling assembly should not provide continuous paths for the spread of fire and smoke, nor an unlimited area for the development of a fire.

- F.4.3 The roof-ceiling surface should have flame spread characteristics related to the room use.
- F.4.4 The roofing material should not be susceptible to ignition from sparks and firebrands.
- F.4.5 Any smoke generated by the roof-ceiling assembly in a fire should not exceed safe limits.

- F.5.1 See E.5.1

- F.6.1 See L.6

- F.7.1 Flat-roof deck constructions should be protected against entrapment of moisture (excessive condensation) from below and from water leakage through the roofing.
- F.7.2 In flat- or near-flat-roof construction with an air separation between ceiling and roofing membrane, provision should be made for protection against moisture condensation.
- F.7.3 Effective ventilation in all attic spaces between roofs and top floor ceilings should be provided.
- F.7.4 There should be a limitation on heat transfer through ceilings.
- F.7.5 A vapor barrier should be used in slab-on-grade construction to prevent transmission of earth moisture into the living space.
- F.7.6 Adequate ventilation and ground cover to basement-less spaces should be provided.
- F.7.7 Heat loss through floors over unheated spaces or on grade should be limited.

- F.8.1 Roofing membrane should withstand the natural environment with regard to temperature and moisture changes and sunlight.
- F.8.2 Provision should be made to prevent the penetration of water from outside by leakage or wind-driven rain.
- F.8.3 Anticipated wind loads should be withstood.
- F.8.4 Impacts from falling objects should be withstood by the roofing membrane.

- F.9.1 For design of roof guard rails see L.3.

- G.1.1 Fixtures and hardware and their connections with structural elements should comply with the deflections permitted in supporting and non-supporting structural elements.
- G.1.2 The serviceability of fixtures and hardware should not be impaired by occupancy loads.
- G.2.1 Fixtures and hardware should be securely attached and should transmit their loads to the structure with an acceptable level of protection against failure of any part of the structure.

- G.3.1 For plumbing fixtures see H.3; for fixtures in general see L.3.
- G.4.1 No requirement at present.
- G.5.1 Fixtures and hardware should perform their intended function without excessive additional noise generation or comprise of the acoustical performance of other building elements.
- G.6.1 See K.6.1 for lighting elements.
- G.7.1 No requirement at present.
- G.8.1 The building hardware for doors, windows, kitchens and bathrooms should have proven durability and conform to recognized standards for individual items.
- G.8.2 Adequate mail-handling facilities should be provided.
- G.9.1 See L.9.
- H.1.1 The plumbing system should be designed to accommodate the allowable deflections of structural elements without impairment of function of the plumbing.
- H.1.2 Vibrations induced by plumbing equipment should not impair structural serviceability of plumbing or structural elements of the building.
- H.1.3 Structural loads imposed on the plumbing system by normal external and internal forces, and normal structural loads imposed by the plumbing system on other subsystems should not interfere with the proper functioning of any subsystem and should not result in loss of stability or integrity.
- H.2.1 Inserts and hangers should not fail and/or damage structural elements to which they are attached.
- H.2.2 Structural safety should not be impaired by the installation of plumbing elements.
- H.3.1 The minimum numbers of plumbing fixtures considered essential for good health and sanitation should be provided.
- H.3.2 No plumbing system or portion thereof should leak when subjected to normal service pressure differentials.
- H.3.3 An adequate hot water supply should be provided.
- H.3.4 Equipment used for heating water or storing hot water should be suitably protected against excess pressure and/or temperature to avoid rupture and/or explosion of components of the hot water supply system and to avoid scalding of users.

- H.3.5 Plumbing systems should consume the minimum quantities of water consistent with the user needs relating to health and sanitation; with proper functioning and cleansing of plumbing fixtures, appliances and equipment; and with the maintenance of adequate, self-cleansing, but not excessive, flow velocities in drainage piping.
- H.3.6 No material, form of construction, fixture, device, appurtenance, or item of equipment should be employed that could introduce toxic substances, impurities, bacteria, or chemicals into a portable water system in quantities sufficient to cause disease or harmful physiological effects.
- H.3.7 Plumbing systems including piping, plumbing fixtures, plumbing appliances and other plumbing equipment should not contribute to the entry or growth of vermin or rodents.
- H.3.8 The sanitary DWV system should function under normal conditions of use so as to avoid the emission of sewer gases or foul air, or the ejection of suds or liquids inside the building through combined hydraulic and pneumatic action.
- H.3.9 Waste water and sewage should be removed from the premises and transported to an acceptable point of disposal at the rates normally discharged from the fixtures and other water-connected equipment without overflowing or accumulating within the premises or backing up into idle fixtures, or without interfixture flow retardation as a result of hydrostatic or hydrodynamic action.
- H.3.10 Water should be supplied in sufficient volume and flow rates and with adequate (but not excessive) pressures so that plumbing fixtures, plumbing appliances, etc., can perform their essential function without excessive wear and noise under normal conditions of use.
- H.3.11 Structural elements and the exterior envelope of the building should by some means be protected from damage from storm water. One acceptable means is by interception and transport of storm water to an acceptable point of disposal.
- H.4.1 The plumbing system and its associated fixtures should not contribute to the spread of fire in the overall structure.
- H.4.2 See H.4.3, I.8.6.1(b), I.8.6.4 and L.4.0.
- H.4.3 Trash rooms, laundry rooms and other hazardous areas must be protected against minor fires.
- H.4.4 To provide water for fire fighting at any level in a building.
- H.5.1 The plumbing system should perform its intended function without excessive additional noise generation or any compromise of the acoustical performance of other building elements.
- H.6.1 See K.6 and L.6.
- H.7.1 Formation of condensation on piping and plumbing equipment should be prevented.

- H.8.1 A reasonable planned life expectancy of the plumbing system and its parts should be defined.
- H.8.2 The piping, plumbing fixtures and plumbing appliances and other plumbing equipment should be of durable material, free of defects and capable of giving satisfactory service for their planned life expectancy under normal conditions of use.
- H.8.3 The quality of design and installation of plumbing systems and plumbing equipment should be such as to provide a reasonable assurance of durability and reliability in relation to essential intended functions for their planned life expectancy under normal conditions of use.
- H.8.4 The design and installation of plumbing systems and equipment should be such as to assure practical maintainability and continuity of service by providing convenience for cleaning, servicing, adjusting or replacing the various elements or components, by minimizing conditions that can contribute to soiling, deposition, fouling, clogging, or other maintenance problems; and by minimizing conditions that can result in interruption of essential function.
- H.8.5 Provision should be made to minimize the danger of freezing of the plumbing system.
- H.8.6 The dangers of premature failure or excessive maintenance relating to corrosion or deposition of carbonates or other matter should be minimized by giving appropriate consideration to the character of the water supply, the soil, the properties of the materials and other pertinent environmental factors.
- H.9.1 For size and location requirements of plumbing fixtures see L.9.
- I.1.1 Mechanical equipment and appliances should accommodate the deflections of structural elements.
- I.1.2 The operation of the mechanical equipment and appliances should not cause excessive transient or steady-state vibrations in the structural system.
- I.2.1 The mechanical equipment and appliances should transmit their static and/or dynamic loads to the structure with an acceptable level of protection against failure of any part of the structure including the connection of the system to the structure.
- I.2.2 Structural safety should be unimpaired by the installation of mechanical equipment and appliances.
- I.3.1 The heating and cooling system and all its auxiliaries should be designed and installed in a manner so that operation and maintenance will not cause health hazard or bodily injury to the building occupants, maintenance personnel or outside contractors.

- I.4.1 The HVAC system should not contribute to a fire, nor should it provide passageways for a fire to travel along the system.
- I.4.2 If individual heating or combustion devices are provided in apartments, a fire caused by the malfunctioning of these devices should not prevent evacuation in case of fire.
- I.4.3 A combustion or other type of heating unit in a dwelling unit should not contribute to fire hazard.

- I.5.1 Mechanical equipment and appliances should perform their intended functions without excessive additional noise or compromise of the acoustical performance of other building elements.

- I.6.1 Equipment rooms, furnace or boiler rooms, and rooms for other mechanical equipment should be properly lighted for work and safety.

- I.7.1 Safe, reliable, comfortable and adequate air conditioning (heating and winter humidity control, and, if furnished, cooling and summer humidity control) should be provided for all occupied spaces.
- I.7.2 The formation of condensation of air conditioning supply ducts, and/or duct coverings should be prevented.
- I.7.3 The humidity level in areas of high humidity sources should be controlled.

- I.8.1 Duct systems, including casings, acoustical treatment, and jointing materials should perform their intended function in a heating or cooling system without excessive maintenance or unsatisfactory deterioration.
- I.8.2 The entire HVAC system should operate reliably without excessive maintenance and should provide for maintenance.
- I.8.3 There should be safe, adequate and convenient vertical transportation for people and property.
- I.8.4 If the means for cooking food in each living unit is provided, it should be of suitable capacity, function, safety, durability and appearance.
- I.8.5 If a means is provided for the refrigerated storage of food in each living unit, it should be of suitable capacity, function, safety, durability and appearance.
- I.8.6 Safe, adequate and convenient means for removal of garbage and trash should be provided.
- I.8.7 Mechanical equipment furnished as a necessary or required part of multifamily housing, including those items specifically covered in this and other sections of this document, should perform its intended function in a safe, adequate and effective manner.

- I.9.1 For location requirements of HVAC controls, see I.7.1.2(b).
- J.1.1 Power and communication lines, interfacing with the building foundations, should not be damaged by a reasonable settlement of the structure.
- J.2.1 Structural safety should be unimpaired by the installation of power and communication elements.
- J.3.1 See J.4 and J.8.
- J.4.1 The power, electrical distribution and communications systems should not impair the fire resistance of rated walls, partitions, and floors.
- J.4.2 Provision should be made for a zoned alarm, non-coded fire alarm system.
- J.4.3 Every public space, hallway, stairway, and other means of egress should have exit illumination and emergency lighting and be properly marked.
- J.4.4 Lightning protection should be provided.
- J.4.5 See J.8.
- J.5.1 Power, electrical distribution, and communications systems should perform their intended functions without excessive noise generation or compromise of the acoustical performance of other building elements.
- J.6.1 No requirement at present.
- J.7.1 No requirement at present.
- J.8.1 The main electrical supply system to the building should be adequate and safe.
- J.8.2 Adequate and safe distribution of electric power to and throughout each living unit should be provided, including a system of wiring equipment and appurtenances properly installed to safely supply electrical energy for adequate illumination and for efficient operation of essential and appropriate appliances and equipment.
- J.8.3 If furnished or required, adequate stand-by electric power should be provided for operation of certain critical items in the event of failure of the customary electric power source. (Note requirements for emergency safety lighting and alarm systems listed in J.4).
- J.8.4 Means for telephone service in each living unit should be provided.

- J.8.5 Means should be provided for at least voice communication between each living unit and the main entrance(s) and/or building reception area.
- J.8.6 Master FM and television signal distribution system should be provided.
- J.9.1 No requirement at present.
- K.1.1 The mounting of the lighting elements should not cause any damage to ceilings during the life of the building.
- K.2.1 A suitable level of protection should be provided against failure of the connections between lighting elements and the structure.
- K.3.1 See K.4, K.6 and L.4.
- K.4.1 Lighting elements should not be a source of fire hazard.
- K.4.2 Non-metallic parts of lighting elements integrated with the HVAC system should not contribute to the overall fire hazard.
- K.4.3 Any smoke generated by the non-metallic parts of lighting elements integrated with the HVAC system should not exceed safe limits.
- K.5.1 Lighting elements should perform their intended function without excessive noise generation and without compromising the acoustical performance of other building elements.
- K.6.1 A means for adequate and safe artificial light to all occupied and utility spaces should be provided.
- K.7.1 No requirement at present.
- K.8.1 See Criterion K.6.1.1(d).
- K.9.1 For location and performance requirements of lighting elements see K.6.1.1, L.6.2.1 and L.4.2.8.
- L.1.1 No requirement at present.
- L.2.1 No requirement at present.
- L.3.1 The residential building and all its parts should be so designed as to assure, to the extent possible in the features of construction, that accidents shall not occur to the occupants; such features to have a usable life span equal to that expected of the structure, or if normally of more limited duration of use, to be readily replaceable by features providing at least equivalent safety.
- L.3.2 The sources of and causes leading to falls, either on the same level or from one level to another, should be eliminated or minimized (applicable to living units, corridors, stairs, public spaces, and exterior walkways).

- L.3.3 To the extent possible the building should be designed and equipped to provide the maximum possible security from the criminal actions to the permanent and transient occupants thereof, and to their possessions.
- L.3.4 Housing proposed specifically for occupancy the elderly and certain others with limited handicaps should meet the intent of the following Criteria in addition to all the other safety criteria. for the guidance of housing for OPERATION BREAKTHROUGH.
- L.3.5 See I.3, L.4 and L.9.
- L.4.0 Fire protection should be provided in designated spaces.
- L.4.1 All doors other than intra dwellings should be able to contain a fire.
- L.4.2 A system of protected public passageways which permits evacuation of occupants should be provided.
- L.5.1 Noise levels in residential interior spaces should be controlled.
- L.6.1 Provision should be made for admission of natural light.
- L.6.2 Adequate levels of artificial lighting at certain locations should be provided.
- L.7.1 Ventilation should be sufficient to create a healthful and relatively odor-free environment within the living units and public spaces and to provide enough circulation of air to prevent conditions conducive to deterioration within the structure.
- L.7.2 The rate of uncontrolled air infiltration into the living space should be limited.
- L.7.3 Provision should be made for conditioning of intake air.
- L.8.1 No requirement at present.
- L.9.1 (a) The design and planning of living units should have a workable man-centered basis. Provision should be made for the essential needs of people for space, light, food, water, sleep, safety, sanitation, comfort, companionship and periods of quietness. It is necessary that adequate housing quality be provided, yet reconciled with minimum cost by the efficient use of space.
(b) Space needs should be determined by family size, the functions of day to day living and the normal possessions of the family. Living units should be planned to contain space sufficient to accomodate appropriate furniture or equipment for each habitable room. To demonstrate the furnishability, preliminary floor plans for each living unit design should show the appropriate furniture drawn to scale.

- L.9.1 (c) The arrangement of rooms should show a proper relationship one to the other, and provide reasonable privacy by (1) locating exterior openings in relation to exterior conditions and (2) having bathrooms accessible from bedrooms and other habitable rooms.
- (d) The circulation pattern throughout a living unit should function satisfactorily. Serious conflicts in the appropriate use of each room and its furniture and equipment should be avoided.
- (e) Single-family houses and multiple living units at or near grade should have a convenient relationship to outdoor areas.
- (f) The indoor space needs for family recreation and self-service activities should be provided for: (play space for children, minor repairs, etc.).
- L.9.2 Each living unit should contain space that is conducive to general family living activities, among which are entertaining, reading, writing, listening to music, watching television, relaxing and frequently children's play. Unless specifically provided for elsewhere in the unit, appropriate space for these activities should be provided in the living area.
- L.9.3 Each living unit should contain space for the purpose of dining. This area may be combined with the living room or kitchen, or may be a separate room.
- L.9.4 The basic activities in the kitchen consist of food preparation, serving and clean up after the meal. The kitchen design should permit efficient operation in the performance of these functions. In addition, storage space for staples, dinnerware and utensils should be provided.
- L.9.5 Facilities should be provided for household laundry needs.
- L.9.6 Each dwelling unit should have space(s) allocated to sleeping and such related activities as dressing and personal care, and study or reading. Sufficient space should also be provided for clothes storage and housekeeping in the bedroom areas.
- L.9.7 Each dwelling unit should have a bathroom with enough area to accommodate a lavatory, a water closet and a bathtub or shower. Arrangement for fixtures should provide for comfortable use of each fixture and permit at least a 90 degree door swing unless sliding doors are used.
- L.9.8 Sufficient closets and storage space should be provided for living and housekeeping within each living unit. All closets and storage spaces should be appropriately located in relation to their principal uses.
- L.9.9 Support facilities should be provided.

R E Q U I R E M E N T D I R E C T O R Y

A. STRUCTURE

1 STRUCTURAL SERVICEABILITY

- A.1.1 Vertical deflection
- A.1.2 Wind-induced drift
- A.1.3 Horizontal deflection
- A.1.4 Foundation settlement
- A.1.5 Vibration
- A.1.6 Occupancy loads
- A.1.7 Volume change of structural elements

2 STRUCTURAL SAFETY

- A.2.1 Failure under extreme load
- A.2.2 Failure under repeated service load
- A.2.3 Progressive failure
- A.2.4 Catastrophic loading
- A.2.5 Foundation settlement
- A.2.6 Inserts and hangers
- A.2.7 Service system installation

3 HEALTH AND SAFETY

- A.3.1 (See page for referral)

4 FIRE SAFETY

- A.4.1 Fire endurance
- A.4.2 Potential heat
- A.4.3 Durability of fire protection material

5 ACOUSTIC ENVIRONMENT

- A.5.1 Sound-generating vibration

6 ILLUMINATED ENVIRONMENT

- A.6.1 (No requirement at present)

7 ATMOSPHERIC ENVIRONMENT

- A.7.1 (See page for referral)

8 DURABILITY/TIME RELIABILITY (FUNCTION)

- A.8.1 Moisture protection
- A.8.2 Climatic conditions
- A.8.3 Excessive deflection

9 SPATIAL CHARACTERISTICS AND ARRANGEMENT

- A.9.1 (No requirement at present)

B. INTERIOR SPACE DIVIDERS
WALLS, DOORS, INTER-DWELLING

1 STRUCTURAL
SERVICEABILITY

- B.1.1 Horizontal deflection
- B.1.2 Foundation settlement
- B.1.3 Occupancy loads

2 STRUCTURAL
SAFETY

- B.2.1 Failure under extreme loads

3 HEALTH AND
SAFETY

- B.3.1 (See page for referral)

4 FIRE
SAFETY

- B.4.1 Fire endurance
- B.4.2 Flame spread
- B.4.3 Smoke
- B.4.4 Potential heat

5 ACOUSTIC
ENVIRONMENT

- B.5.1 Acoustical privacy between units

6 ILLUMINATED
ENVIRONMENT

- B.6.1 (See page for referral)

7 ATMOSPHERIC
ENVIRONMENT

- B.7.1 (No requirement at present)

8 DURABILITY/TIME
RELIABILITY (FUNCTION)

- B.8.1 (See page for referral)

9 SPATIAL CHARACTERISTICS
AND ARRANGEMENT

- B.9.1 (See page for referral)

C. INTERIOR SPACE DIVIDERS
WALLS AND DOORS, INTRA-DWELLING

1 STRUCTURAL
ENVIRONMENT

C.1.1 (See page for referral)

2 STRUCTURAL
SAFETY

C.2.1 Failure under extreme
load

3 HEALTH AND
SAFETY

C.3.1 (See page for referral)

4 FIRE
SAFETY

C.4.1 Fire and smoke paths

C.4.2 Flame spread

C.4.3 Smoke

C.4.4 Fire endurance

C.4.5 Potential heat

5 ACOUSTIC
ENVIRONMENT

C.5.1 Acoustical privacy
within unit

6 ILLUMINATED
ENVIRONMENT

C.6.1 (See page for referral)

7 ATMOSPHERIC
ENVIRONMENT

C.7.1 (No requirement
at present)

8 DURABILITY/TIME
RELIABILITY (FUNCTION)

C.8.1 Wall finish

9 SPATIAL CHARACTERISTICS
AND ARRANGEMENT

C.9.1 (See page for referral)

D. INTERIOR SPACE DIVIDERS
FLOOR-CEILING

1 STRUCTURAL
SERVICEABILITY

- D.1.1 Vertical deflection
- D.1.2 Foundation settlement
- D.1.3 Vibration
- D.1.4 Occupancy loads
- D.1.5 Occupancy loads and
serviceability of
fixtures

2 STRUCTURAL
SAFETY

- D.2.1 Failure under
extreme load

3 HEALTH AND
SAFETY

- D.3.1 (See page for referral)

4 FIRE
SAFETY

- D.4.1 Fire endurance
- D.4.2 Flame spread
- D.4.3 Smoke
- D.4.4 Potential heat

5 ACOUSTIC
ENVIRONMENT

- D.5.1 Acoustical privacy
between units
- D.5.2 Acoustical privacy
between levels

6 ILLUMINATED
ENVIRONMENT

- D.6.1 (See page for
referral)

7 ATMOSPHERIC
ENVIRONMENT

- D.7.1 (No requirement
at present)

8 DURABILITY/TIME
RELIABILITY (FUNCTION)

- D.8.1 Floor surface - living,
dining, sleeping
- D.8.2 Floor surface - bath,
laundry, kitchen

9 SPATIAL CHARACTERISTICS
AND ARRANGEMENT

- D.9.1 (No requirement at
present)

E. EXTERIOR ENVELOPE
WALLS, DOORS AND WINDOWS

1 STRUCTURAL
SERVICEABILITY

- E.1.1 Occupancy loads
- E.1.2 Horizontal deflection
- E.1.3 Foundation settlement
- E.1.4 Volume change of structural elements

2 STRUCTURAL
SAFETY

- E.2.1 Failure under extreme load

3 HEALTH AND
SAFETY

- E.3.1 (See page for referral)

4 FIRE
SAFETY

- E.4.1 Fire endurance
- E.4.2 Flame spread
- E.4.3 Smoke
- E.4.4 Potential heat
- E.4.5 Smoke or flame paths

5 ACOUSTICAL
ENVIRONMENT

- E.5.1 Outside noise

6 ILLUMINATED
ENVIRONMENT

- E.6.1 (See page for referral)

7 ATMOSPHERIC
ENVIRONMENT

- E.7.1 Thermal resistance
- E.7.2 Thermal breaks to prevent condensation
- E.7.3 Air infiltration
- E.7.4 Water penetration
- E.7.5 Water infiltration through foundation
- E.7.6 Condensation in walls
- E.7.7 Windows
- E.7.8 Doors

8 DURABILITY/TIME
RELIABILITY (FUNCTION)

- E.8.1 Sealing of joints
- E.8.2 Protection of exterior coating
- E.8.3 Exterior cladding
- E.8.4 Thermal expansion
- E.8.5 Exterior doors

9 SPATIAL CHARACTERISTICS
AND ARRANGEMENT

- E.9.1 Proximity to child play areas
- E.9.2 (See page for referral)

F. EXTERIOR ENVELOPE
ROOF-CEILING, GROUND FLOOR

1 STRUCTURAL
SERVICEABILITY

F.1.1 Vertical deflection

F.1.2 Vibration

2 STRUCTURAL
SAFETY

F.2.1 Failure under
extreme load

3 HEALTH AND
SAFETY

F.3.1 (See page for
referral)

4 FIRE
SAFETY

F.4.1 Fire endurance

F.4.2 Fire and smoke paths

F.4.3 Flame spread

F.4.4 Roof susceptibility
to ignition

F.4.5 Smoke

5 ACOUSTIC
ENVIRONMENT

F.5.1 (See page for
referral)

6 ILLUMINATED
ENVIRONMENT

F.6.1 (See page for
referral)

7 ATMOSPHERIC
ENVIRONMENT

F.7.1 Moisture and flat-roof
deck construction

F.7.2 Moisture and flat- or
near-flat roof

F.7.3 Attic ventilation

F.7.4 Heat transfer through
ceilings

F.7.5 Transmission of
earth moisture

F.7.6 Ventilation of
basementless space

F.7.7 Heat loss over
unheated spaces

8 DURABILITY/TIME
RELIABILITY FUNCTION

F.8.1 Natural environment
and roofing membrane

F.8.2 Water penetration

F.8.3 Wind loads

F.8.4 Roofing membrane
resistance to impact

9 SPATIAL CHARACTERISTICS
AND ARRANGEMENT

F.9.1 (See page for
referral)

- G. FIXTURES AND HARDWARE
- 1 STRUCTURAL
 SERVICEABILITY
- G.1.1 Deflection
- G.1.2 Occupancy loads
- 2 STRUCTURAL
 SAFETY
- G.2.1 Transmission of load
- 3 HEALTH AND
 SAFETY
- G.3.1 (See page for
 referral)
- 4 FIRE
 SAFETY
- G.4.1 (No requirement
 at present)
- 5 ACOUSTIC
 ENVIRONMENT
- G.5.1 Noise
- 6 ILLUMINATED
 ENVIRONMENT
- G.6.1 (See page for
 referral)
- 7 ATMOSPHERIC
 ENVIRONMENT
- G.7.1 (No requirement
 at present)
- 8 DURABILITY/TIME
 RELIABILITY (FUNCTION)
- G.8.1 Durability of hardware
- G.8.2 Mail-handling facilities
- 9 SPATIAL CHARACTERISTICS
 AND ARRANGEMENT
- G.9.1 (See page
 for referral)

H. PLUMBING

1 STRUCTURAL SERVICEABILITY

- H.1.1 Deflection
- H.1.2 Vibration
- H.1.3 Structural loads

2 STRUCTURAL SAFETY

- H.2.1 Inserts and hangers
- H.2.2 Installation

3 HEALTH AND SAFETY

- H.3.1 Number of fixtures
- H.3.2 Leakage
- H.3.3 Hot water supply
- H.3.4 Protection of water-heating equipment
- H.3.5 Water quantity; user needs
- H.3.6 Water potability
- H.3.7 Resistance to entry of vermin
- H.3.8 Improper emission of gases or liquids
- H.3.9 Overflow or back-up
- H.3.10 Water pipe sizing
- H.3.11 Storm water disposal

4 FIRE SAFETY

- H.4.1 Fire endurance
- H.4.2 (See page for referral)
- H.4.3 Hazardous areas
- H.4.4 Water for fire fighting

5 ACOUSTIC ENVIRONMENT

- H.5.1 Noise

6 ILLUMINATED ENVIRONMENT

- H.6.1 (See page for referral)

7 ATMOSPHERIC ENVIRONMENT

- H.7.1 Condensation

8 DURABILITY/TIME RELIABILITY (FUNCTION)

- H.8.1 System life expectancy
- H.8.2 Fixtures and appliances
- H.8.3 Installation
- H.8.4 Access
- H.8.5 Freezing
- H.8.6 Corrosion

9 SPATIAL CHARACTERISTICS AND ARRANGEMENT

- H.9.1 (See page for referral)

I. MECHANICAL EQUIPMENT, APPLIANCES

1	STRUCTURAL SERVICEABILITY	8	DURABILITY/TIME RELIABILITY (FUNCTION)
I.1.1	Deflection	I.8.1	Durability of duct systems
I.1.2	Vibration	I.8.2	Durability of HVAC system
2	STRUCTURAL SAFETY	I.8.3	Elevators
I.2.1	Transmission of load	I.8.4	Ranges and ovens
I.2.2	Installation	I.8.5	Refrigerators
3	HEALTH AND SAFETY	I.8.6	Garbage and trash removal
I.3.1	Inherent hazards	I.8.7	Mechanical equipment (general)
4	FIRE SAFETY	9	SPATIAL CHARACTERISTICS AND ARRANGEMENTS
I.4.1	Fire endurance, fire and smoke paths	I.9.1	(See page for referral)
I.4.2	Location of heating devices		
I.4.3	Safety of heating units		
5	ACOUSTIC ENVIRONMENT		
I.5.1	Noise		
6	ILLUMINATED ENVIRONMENT		
I.6.1	Lighting of mechanical equipment rooms		
7	ATMOSPHERIC ENVIRONMENT		
I.7.1	Heating and cooling		
I.7.2	Condensation on ducts		
I.7.3	Humidity		

J. POWER, ELECTRICAL DISTRIBUTION
COMMUNICATIONS

1 STRUCTURAL
SERVICEABILITY

J.1.1 Settlement of structure

2 STRUCTURAL
SAFETY

J.2.1 Installation

3 HEALTH AND
SAFETY

J.3.1 (See page for referral)

4 FIRE
SAFETY

J.4.1 Fire endurance

J.4.2 Fire alarm system

J.4.3 Emergency lighting
exit illumination

J.4.4 Lightning protection

J.4.5 (See page for
referral)

5 ACOUSTIC
ENVIRONMENT

J.5.1 Noise

6 ILLUMINATED
ENVIRONMENT

J.6.1 (No requirement
at present)

7 ATMOSPHERIC
ENVIRONMENT

J.7.1 (No requirement
at present)

8 DURABILITY/TIME
RELIABILITY (FUNCTION)

J.8.1 Electrical supply
to building

J.8.2 Electrical distribu-
tion to living units

J.8.3 Emergency electric
power

J.8.4 Telephone

J.8.5 Intra-building
communication

J.8.6 Television signal
distribution

9 SPATIAL CHARACTERISTICS
AND ARRANGEMENT

J.9.1 (No requirement
at present)

K. LIGHTING ELEMENTS

1 STRUCTURAL
SERVICEABILITY

K.1.1 Ceiling damage

2 STRUCTURAL
SAFETY

K.2.1 Connections

3 HEALTH AND
SAFETY

K.3.1 (See page for
referral)

4 FIRE
SAFETY

K.4.1 Fire endurance of
lighting elements

K.4.2 Fire endurance of
non-metallic lighting
elements

K.4.3 Smoke

5 ACOUSTIC
ENVIRONMENT

K.5.1 Noise

6 ILLUMINATED
ENVIRONMENT

K.6.1 Lighting of
occupied spaces

7 ATMOSPHERIC
ENVIRONMENT

K.7.1 (No requirement
at present)

8 DURABILITY/TIME
RELIABILITY (FUNCTION)

K.8.1 (See page for
referral)

9 SPATIAL CHARACTERISTICS
AND ARRANGEMENT

K.9.1 (See page
for referral)

L. ENCLOSED SPACES

1 STRUCTURAL
SERVICEABILITY

L.1.1 (No requirement
at present)

2 STRUCTURAL
SAFETY

L.2.1 (No requirement
at present)

3 HEALTH AND
SAFETY

L.3.1 General hazards
L.3.2 Fall hazards
L.3.3 Security
L.3.4 Housing for elderly
L.3.5 (See page for
referral)

4 FIRE
SAFETY

L.4.0 Fire protection
L.4.1 Fire endurance of
doors
L.4.2 Exit system

5 ACOUSTIC
ENVIRONMENT

L.5.1 Noise levels

6 ILLUMINATED
ENVIRONMENT

L.6.1 Natural light
L.6.2 Artificial light

7 ATMOSPHERIC
ENVIRONMENT

L.7.1 Ventilation
L.7.2 Air filtration
L.7.3 Intake air conditioning

8 DURABILITY/TIME
RELIABILITY (FUNCTION)

L.8.1 (No requirement
at present)

9 SPATIAL CHARACTERISTICS
AND ARRANGEMENT

L.9.1 General objectives
L.9.2 Living area
L.9.3 Dining
L.9.4 Kitchen
L.9.5 Laundry
L.9.6 Bedroom
L.9.7 Bath
L.9.8 Closets
L.9.9 Support facilities

